Ambipolar Behavior of Solid-State MoS_2-on-SiO_2 Using Contact Engineering

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Abstract

The dichalcogenide, molybdenum disulfide (MoS_2), a normally indirect bandgap semiconducting material in its bulk form, has nevertheless emerged as an attractive material for novel nanoscale optoelectronic devices due to the large direct bandgap achieved when the bulk is thinned down to only a single- or a few-layered flakes. MoS_2 has a stratified structure of weakly coupled, covalently bonded two-dimensional sheets, and can be mechanically separated through exfoliation techniques, as have been commonly used with graphene. However, optoelectronic devices require electron-hole generation/recombination, so the fabrication of solid-state ambipolar transistors must allow charge transport in both the conduction and valence bands by appropriately shifting the Fermi energy level with an applied gate voltage. Although n-type transistor operation for single- and few-layer MoS_2 has been demonstrated with gold source and drain contacts, transport in the valence band has been elusive for solid-state devices [1].

Here we demonstrate that Schottky barriers of either polarity (p-type or n-type) can be obtained with multilayer MoS_2 flakes exfoliated from geological crystals [2]. We find that MoS_2 channels can be hole-doped using palladium contacts, yielding MoS_2 p-type transistors. When two different materials are used for the source and drain electrodes, for example hole-doping Pd and electron-doping Au, the Schottky junctions formed at the MoS_2 contacts produce a clear photovoltaic effect. The photovoltaic conversion efficiency measured under 532-nm laser irradiation, without any device design optimization, is about 1.25%, making MoS_2 a promising material for flexible photovoltaic applications.

References

[1] Das, S., et al., Nano Letters **13** (2013), 100.

[2] Fontana, M. et al. Scientific Reports **3** (2013) 1634.

Figures

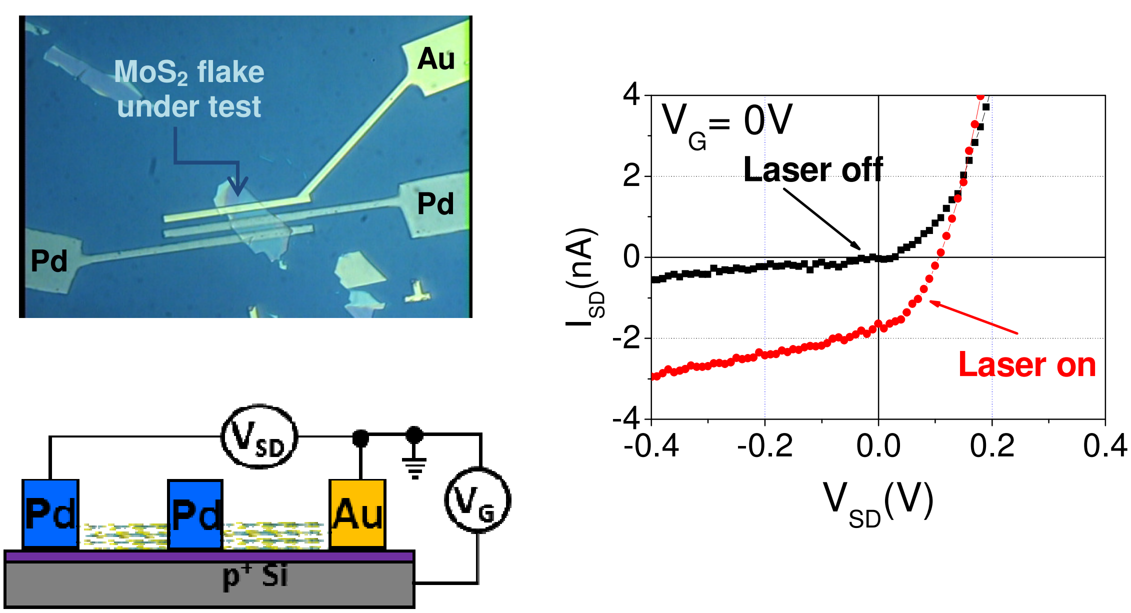

Fig. 1. Optical image, schematic, and photovoltaic response of the MoS_2 device under test [2].